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Barium abundances in cool dwarf stars as a constraint to s- and r-process nucleosynthesis

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Abstract

We revise barium abundances in 11 cool stars with metallicities ranging from -2.65 to 0.05. The results are based on differential NLTE model atmosphere analyses of spectra that have a typical S/N of 200 and a resolution of 40000 or 60000. To minimize systematic errors of theoretical modeling and to be sure that elemental surface abundances are not contaminated by thermonuclear reaction products from the stellar interior the sample is confined to main-sequence and turnoff stars with only two subgiants added. Stellar fundamental parameters are derived from either (V-K) colours or Balmer line profiles for the effective temperature, from HIPPARCOS parallaxes for the surface gravity and from the LTE analyses of the Fe II line profiles for metal abundance and microturbulence values. The statistical equilibrium of Ba II is investigated with a model atom containing 41 levels of Ba II plus the ground state of Ba III. NLTE effects depend on the metallicity of a star: they increase the equivalent widths compared with LTE for [Fe/H] > -2, and they show the opposite behaviour at lower metallicities. Empirical evidence for the necessity to include H atom collisions in the statistical equilibrium of Ba II is found from comparison of Ba abundances in the metal-poor stars derived from the different spectral lines. The formula of Drawin with a scaling factor of 1/3 gives quite sufficient results. [Ba/Fe] abundance ratios are approximately solar above [Fe/H] ~ -2.2 where they decrease rapidly by 0.5-0.6 dex. The direct method based on the hyperfine structure (HFS) of the resonance line of the odd isotopes is suggested to estimate the contribution of the s- and r-process to Ba synthesis. Its application requires the knowledge of the total Ba abundance that can be deduced from the subordinate lines free of HFS. Thus, we cannot estimate the ratio of the s- and r- processes for the two most metal-deficient stars of our sample. Our conclusion is that the s-process dominated Ba production, at least, for the metal-poor stars with [Fe/H] > -2.2.

Keywords

Line: formation, Nuclear reactions, nucleosynthesis, abundances, Stars: abundances, Stars: fundamental parameters, Stars: late-type